Triggering for $\vec{p} + \vec{p}$

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- Anticipated Conditions +
- Physics Goals +
- Trigger Needs & Concerns

for the STAR Spin program (emphasis on FY03 run, with a few comments on longer-term issues)

+ some comments on EEMC trigger patches

Conditions and Goals for FY03 p-p Run

Anticipated Beam Parameters:

- $\sqrt{s}$ = 200 GeV; $\mathcal{L} \approx 1 \times 10^{31}$ cm^{-2}s^{-1} $\approx 10 \times \mathcal{L}_{2001\text{-}2} \approx 0.1 \times \mathcal{L}_{design}$
- $P_{beam} \approx$ 40% from AGS $\Rightarrow$ $\approx$ 35% at 100 GeV $\approx 2 \times P_{2001\text{-}2}$
- 2 wks. change + 3 wks. commission + 3 wks. data @ above $\mathcal{L}$

New Hardware Relevant for Spin:

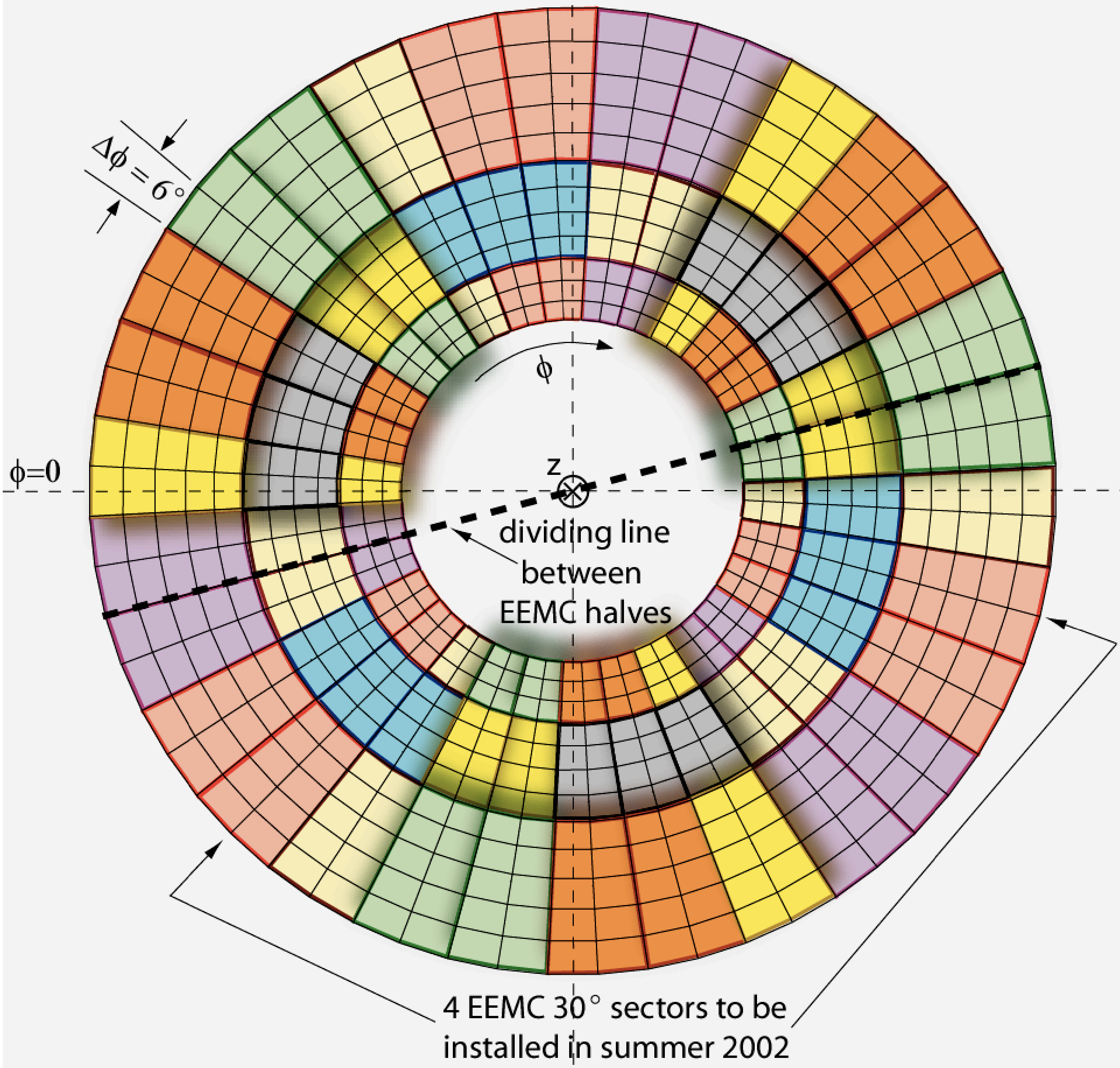
- 4 spin rotators surrounding STAR
- New fast AGS CNI polarimeter
- 1/3 of endcap EMC + full west half of barrel EMC
- Expanded BBC's + completely revamped (?) FPD
- **lots of commissioning + lots of new triggering opportunities**

Physics Goals:

- Extend search for transverse spin asymmetries at both high and mid-η, with much improved statistical precision ($\times$40 in $P^2\mathcal{L}$)
- Begin measurements of A_{LL} for inclusive jet production $\Rightarrow$ first hint of ΔG
- Investigate spin sensitivity of $\mathcal{L}$ monitor for A_{LL}
- Commission spin rotators (need monitor process with $A_T \neq 0$ and significant rate)
- Commission EEMC

EEMC Trigger Patches

(looking west from STAR center)



Individual towers span $\Delta\phi = 0.1 \otimes \Delta\eta = 0.057–0.099$

Small trigger patches, comprising 6, 8 or 10 towers, span $\Delta\phi = 0.2 \otimes \Delta\eta \approx 0.3$

15 small patches combined to form jet patch of $\Delta\phi = 1.0 \otimes \Delta\eta = 1.0$

Within each jet patch, small patches of same color fed to same FEE card

Jet patches chosen to give near left-right & up-down symmetry

Jet patches span physical EEMC sector and half boundaries!

Jet patches should be matched in ϕ *(within 3°)* to BEMC jet patches

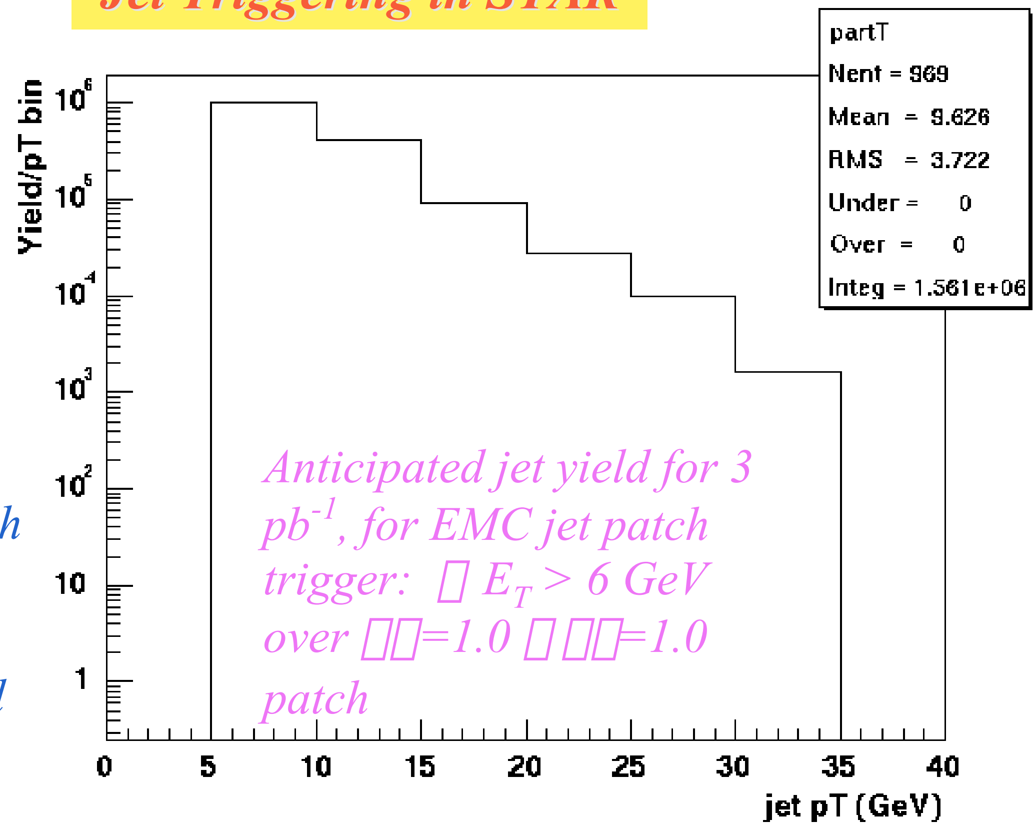
Baseline Triggers for FY03 pp Run

N.B. Threshold values below are illustrative only. Desired values will be chosen closer to run time

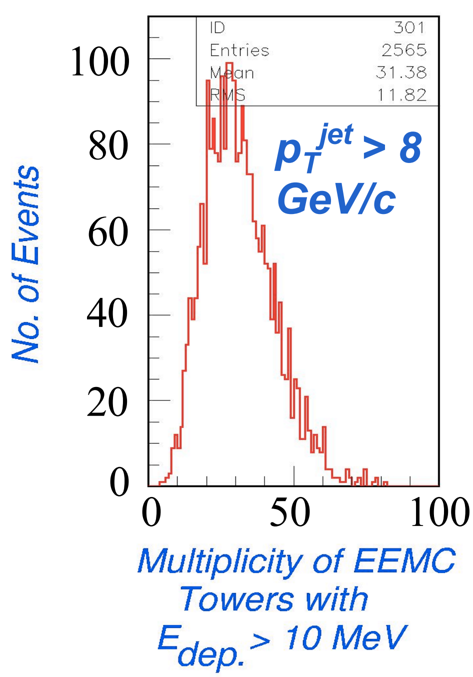
Trigger Type	How Generated	Anticipated Rate @ $L = 1 \times 10^{31}$ cm^{-2}s^{-1}	# Events Anticipated in 10 Days @ 33% Efficiency ($\sim$3 pb^{-1})
High (B+E)EMC Tower	$E_T^{tower} > 5$ GeV @ L0	3 Hz	$\sim 4 \times 10^5$ π^0 @ $p_T > 5$ GeV/c $\sim 2 \times 10^5$ η^0 @ $p_T > 5$ GeV/c $\sim$5-10 K direct γ @ $p_T > 5$ GeV/c $\sim$1K dijets @ $p_T^{hadron} > 5$ GeV/c, $\lvert\Delta\eta\rvert > 2$
	$3 < E_T^{tower} < 5$ GeV @ L0	160÷20 = 8 Hz	$\sim 1 \times 10^6$ π^0 @ $p_T > 3$ GeV/c
Jet	$\Sigma E_T > 6$ GeV over (B+E) EMC jet "patches" @ L0+L2 (also consider lower thresh. correlation w/ # hit EMC towers, for diff. jet bias)	80÷2 = 40 Hz ($\sim$40% dijet events)	$\sim 1 \times 10^6$ jets @ p_T=5-10 GeV/c $\sim$90K jets @ p_T=15-20 GeV/c $\sim$1K jets @ p_T=30-35 GeV/c
Min. Bias	BBC E•W, prescaled	$\sim$40 Hz	$\sim 2 \times 10^6$ min. bias in 2 days
FPD	Depends on new FPD arrangement	≥ 250 Hz, via scalers (small fraction → TPC readout)	$\sim 1 \times 10^6$ events TopE + BotE and TopW + BotW, needed to measure "L" spin orientation to $\sim\pm10^\circ$ in 1 fill, for spin rotator calibration

Jet Triggering in STAR

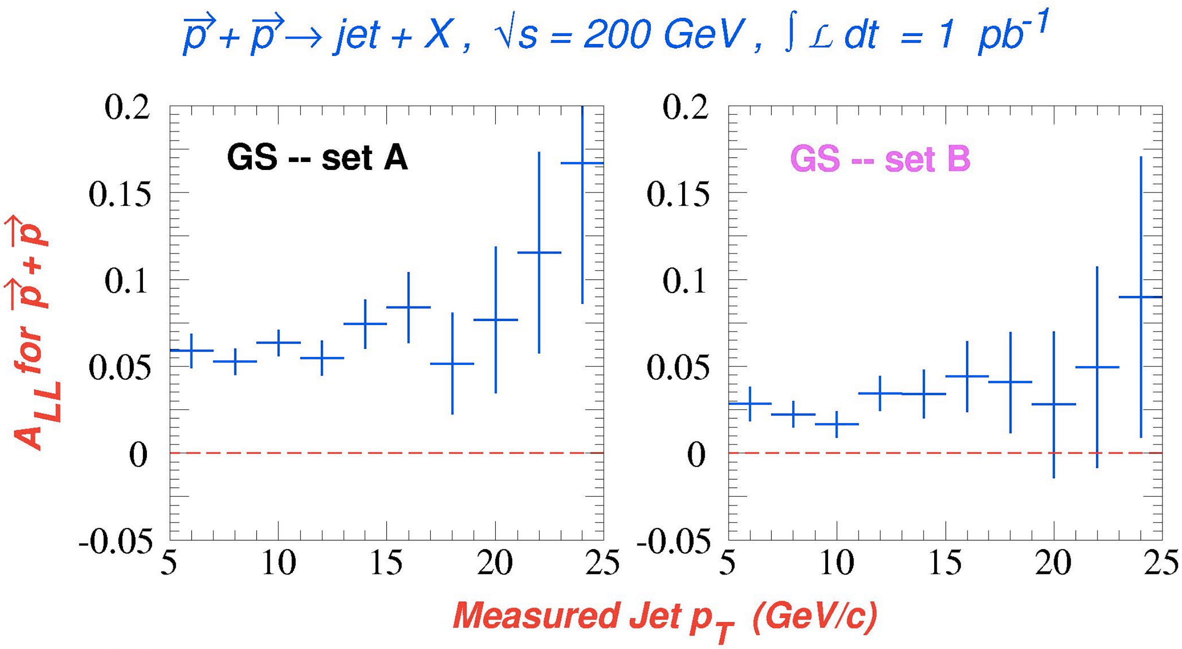
Optimal patch definition may require lower threshold at L0, followed by search of tower ADC values to find optimal patch (centered on jet) at L2, where desired threshold applied.

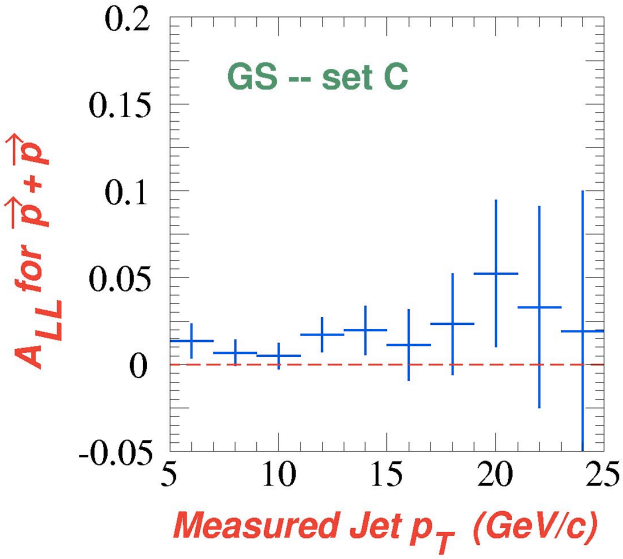


N.B. *Fragmentation function differences between quark and gluon jets $\Rightarrow$ bias in jet triggering. E.g., simulations suggest gg/qq accepted jet ratio varies by factor 2.5 as trigger patch grows from 0.25×0.2 to 1.0×0.8 in $\Delta\eta\times\Delta\phi$ (above 5 GeV threshold). Bias must be understood well to interpret predicted yields and spin effects for jet sample.* $\Rightarrow$ **Take data with two jet triggers of different bias, see if simulations predict changes correctly.** *Multiplicity of hit EMC towers above low threshold is useful complement to ΣE_T, with greater sensitivity to gluons. Not in present thinking for L0, but could be? If so, want 6* **least significant** *bits from EMC ADC's @ L0.*



Sensitivity of Inclusive Jet Asymmetries to $\Delta G(x)$ for RHIC Year 2 (2000-01) $\vec{p} + \vec{p}$ Running at STAR





Simulation assumes:

- ***Year 2 STAR Geometry***
  $\Rightarrow$ 42 BEMC modules in west end
  $0 < \phi < 4.4$; $0 < \eta < 1$
- ***Jet Trigger from BEMC***
  $\Rightarrow \sum E_T > 5$ GeV over at least one BEMC patch of size $(\Delta\eta = 1) \times (\Delta\phi = 0.84)$
- ***Include only jets that are $\approx$ fully contained within BEMC***
  $\Rightarrow (0.35 < \eta_{jet} < 0.65) \times (0.35 < \phi_{jet} < 4.05)$

***The PYTHIA-generated event sample that passes the trigger comprises:** $\approx$ 60% q+g scattering, $\approx$ 25% q+q scattering, $\approx$ 15% g+g scattering*

N.B. *Under anticipated FY03 conditions, we would reach stat. errors about 2× larger than those shown above (due to reduced P) in 3 pb^{-1} – still enough to discriminate among models, BUT …*

Systematic Error Concerns for ΔG Sensitivity of A_{LL}(jets)

Absolute P_{beam} uncertainty (~±20%) $\Rightarrow$ A_{LL} scale uncertainty $\approx$ ±40%

$\Rightarrow$ Need RHIC down-ramping development to reduce uncertainty to perhaps 30%

Trigger bias/fragmentation uncertainties

$\Rightarrow$ Collect data with different jet triggers

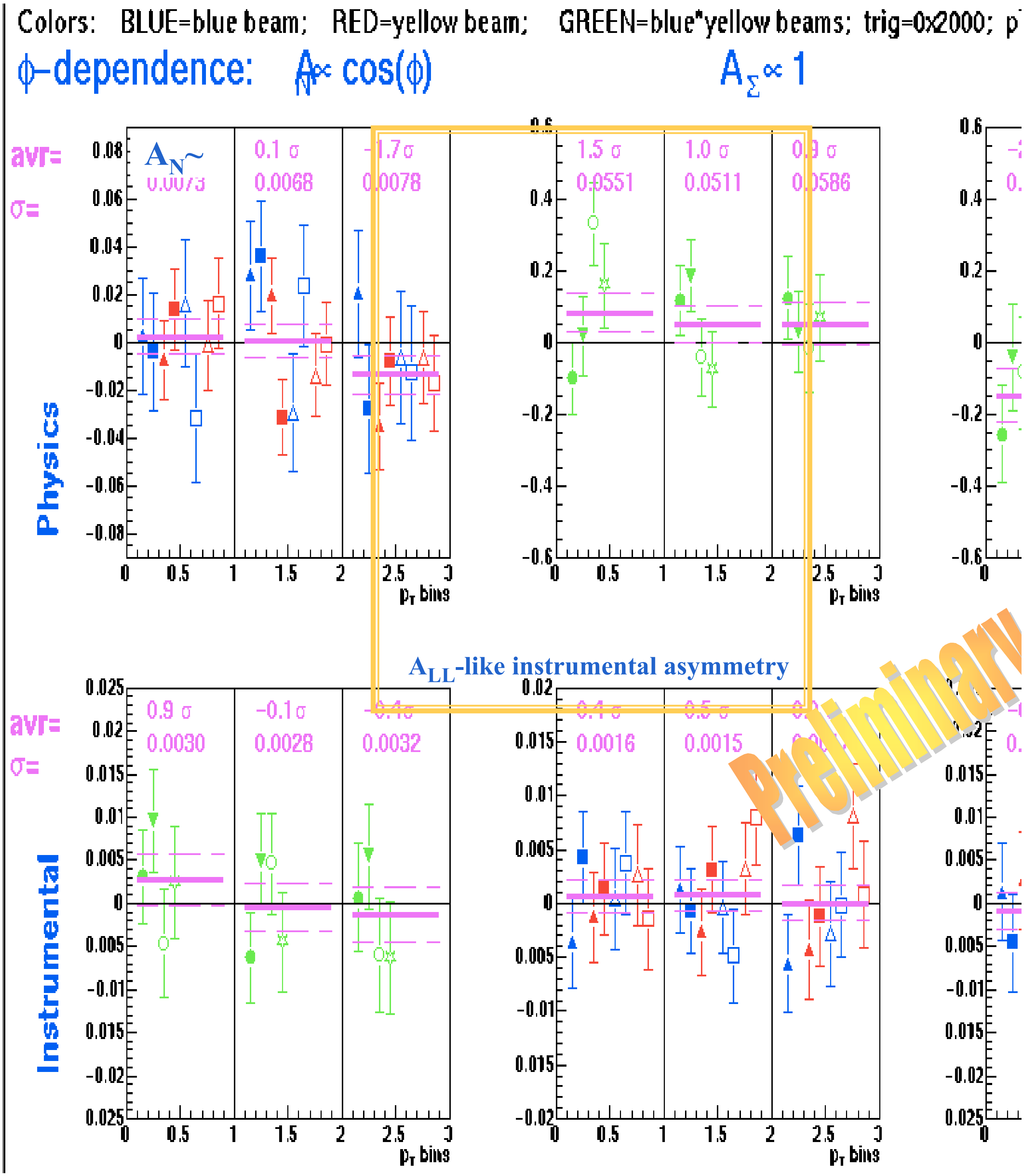
Asymmetries = P^2A_{LL} $\lesssim$ 0.003 $\Rightarrow$ must measure relative L for different spin combinations to at least ±0.001

$\Rightarrow$ Need to scale/compare a few independent high-rate L monitors, since monitoring process may have its own non-zero LL asymmetry (either real or instrumental) – e.g., BBC in different η ranges, FPD, CTB @ low threshold, …

Spin rotators need calibration to know that beam spin is truly longitudinal

$\Rightarrow$ Need non-zero single-spin transverse asymmetries to watch vanish as each beam spin is rotated to L; FPD $\Rightarrow$ best bet. May have to take data at 3 different rotator settings to sort out offline!

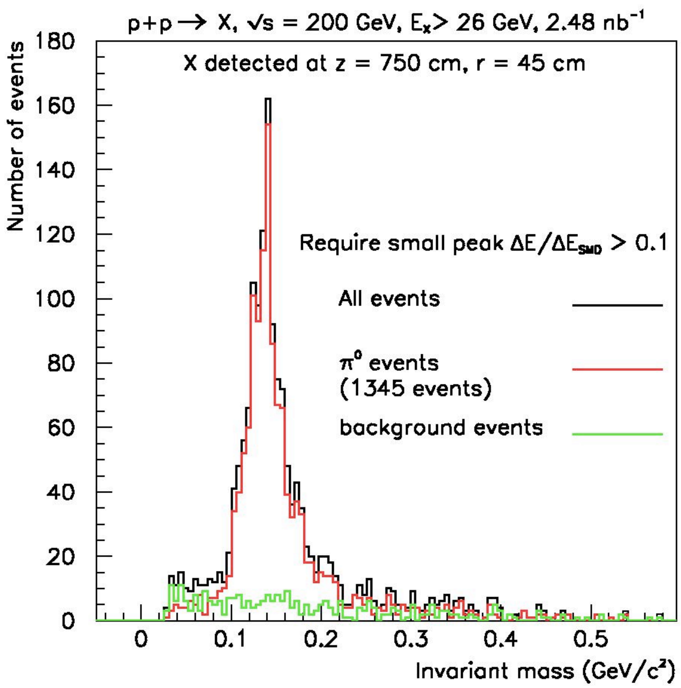
Even with above concerns, should be able to determine sign of ΔG, and this is still important information at this stage!

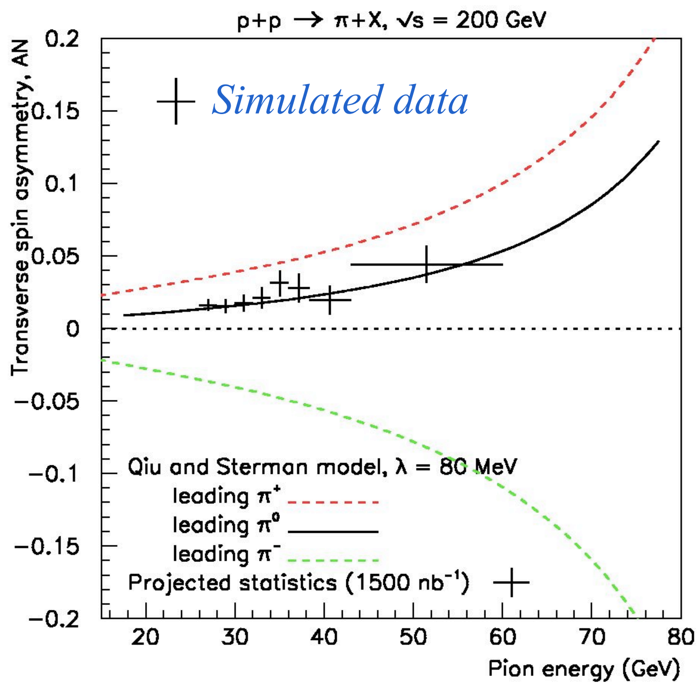


Mid-rapidity leading charged particle analysis from 2001-2 data
→ single-spin transverse asymmetries very small;
possible A_{LL}-like luminosity problem at 2σ level.

Transverse Asymmetries at High η

There is reason to expect appreciable $A_T \neq 0$ for π^0 production in the FPD region, from models extrapolating FNAL E704 results for inclusive π asymmetries to RHIC energies.





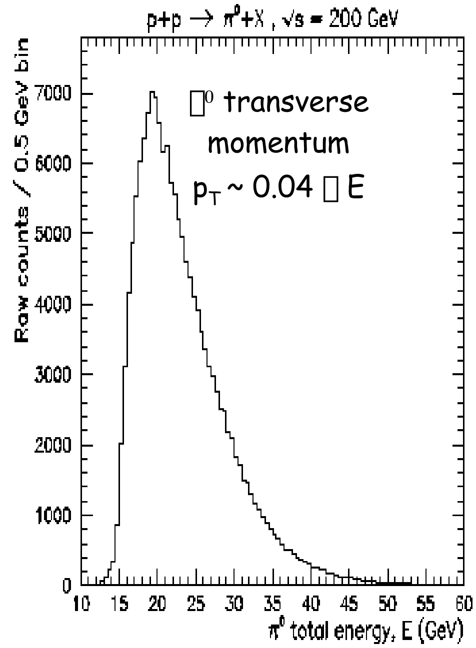
- *Changing theoretical perspective $\Rightarrow$ increasing interest in these single-spin transverse asymmetries of possibly leading twist origin*

- *Data from 2001-2 spin run not conclusive yet: small P_{beam} $\Rightarrow$ very small asymmetries subject to instrumental asymmetries in L-R asymmetric 2001-2 FPD*

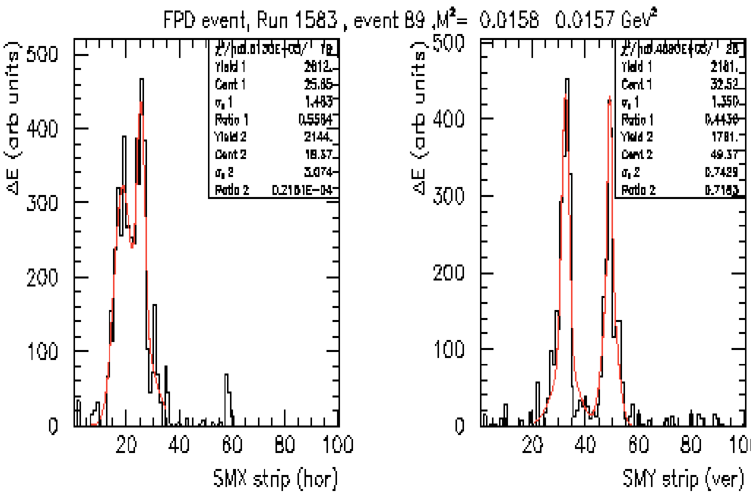
- *π^0's have been clearly reconstructed in prototype EEMC (N FPD calorimeter)*

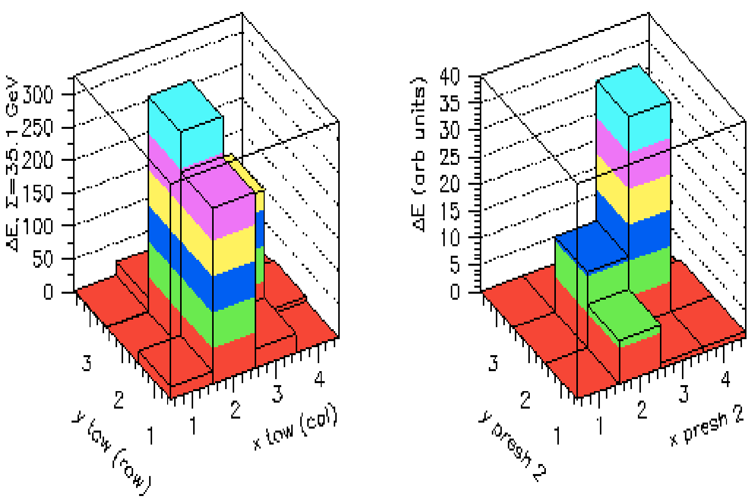
- *New FPD under consideration – More from Les …*

First on-line results for π^0 Discrimination in the Forward Pion Detector (FPD)



- Transverse shower profile response of shower maximum detector:

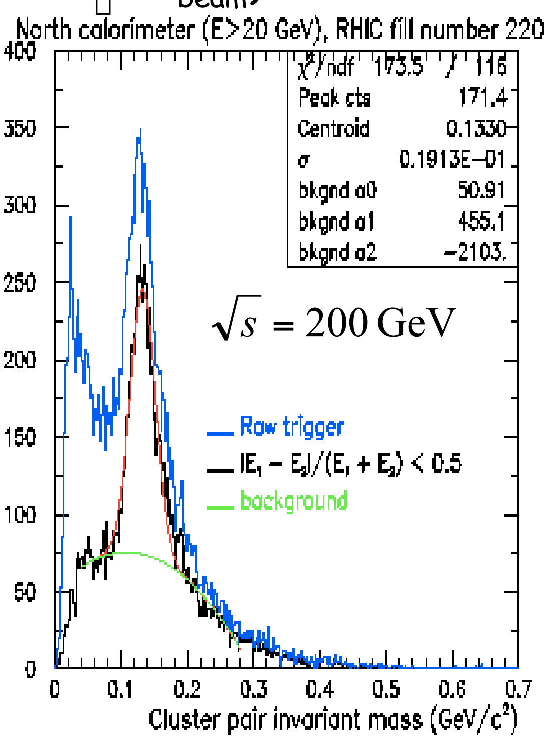




- Calorimeter and pre-shower detector response:

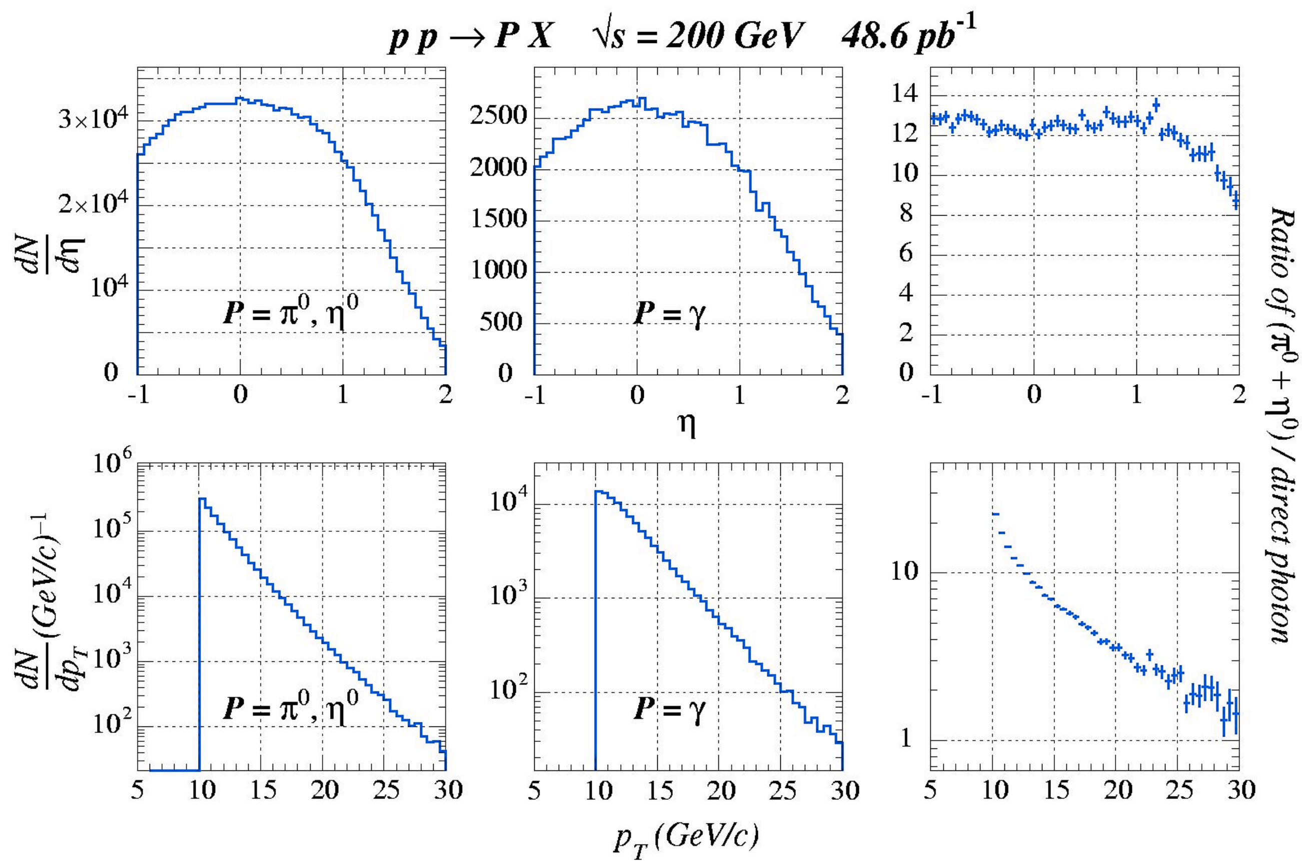
- Cluster separation in shower maximum detector and measured calorimeter energy serves as input to the π^0 mass determination.

- π^0 mass determination up to 60 GeV → Large x_F ($\approx E_{\pi^0}/E_{beam}$)



- Clearly identified π^0 mass peak.

Will also measure inclusive π^0 A_T near mid-rapidity with EMC high-tower trigger



10-day run under anticipated FY03 conditions should permit statistical precision ±0.01 on A_T in p_T bins from 5-6, 6-8, 8-10 GeV/c. Will choose prescale factor for lower p_T trigger to attain comparable precision at lower p_T.

Pileup Filtering at Level 3

At $L = 1 \,\square\, 10^{31}$, 120 bunches filled, expect:

□ 3.3% probability of non-diffractive collision/bunch Xing

□ ~ 25 other collisions to occur within ± TPC drift time from trigger event

□ ~ 150 pileup track segments in TPC for each trigger

□ L3 pileup filter can be usefully employed & tested for essential use at full design luminosity.

Algorithm (Jan Balewski) relies on finding event vertex from tracks leading to prompt hit CTB slabs and EMC towers. Then Level 3 clusters are saved only for tracks consistent with that vertex or prompt scintillator hits.

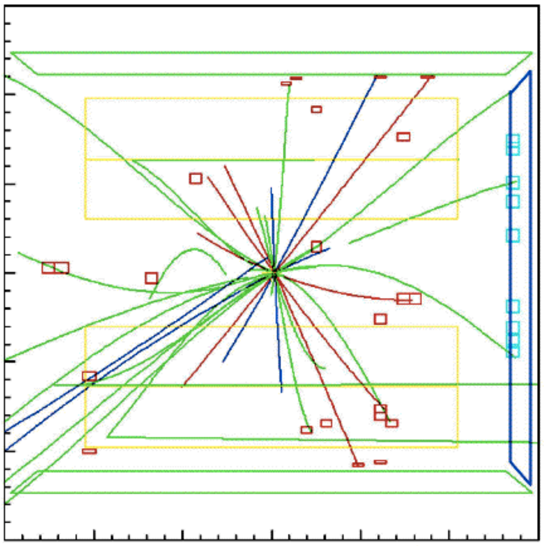
Algorithm has been tested on pp simulations for 2001 run, needs to be tested on data taken during 2001-2, and incorporated in L3 usage for FY03 pp run!

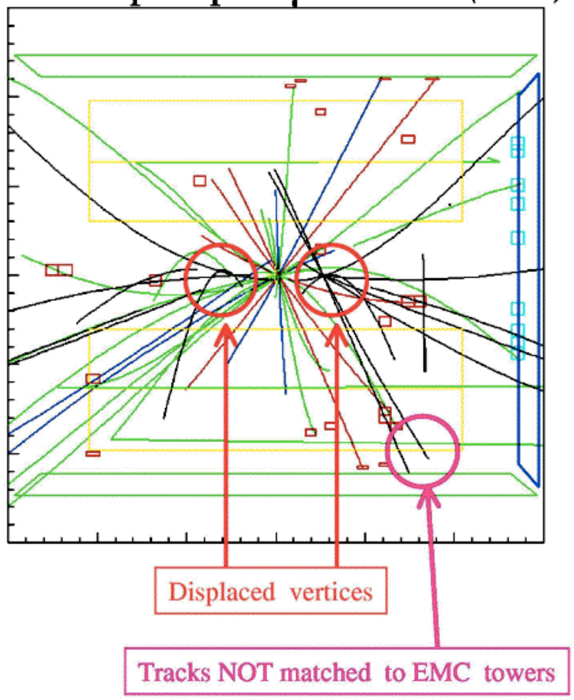
Example of 2 Piledup Events in TPC

Jan Balewski, IUCF
CERN, July 24-25, 2001
High Level Trigger Workshop

trigger p+p event
(p_T >10 GeV) @ 200 GeV

The same trigger p+p event
+ 1 pileup 10μs earlier *(black)*





Color coding :
- green p_T <500 MeV/c
- blue $p_T \in [0.5, 1]$ GeV/c
- red p_T >1 GeV/c

Evaluation of the Pileup Filter

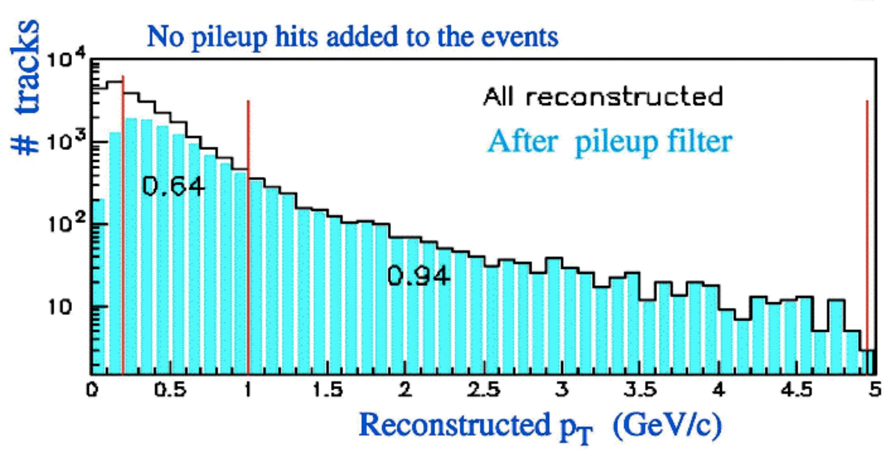
Jan Balewski, IUCF
CERN, July 24-25, 2001
High Level Trigger Workshop

Pileup Filter
accepts tracks (& TPC clusters):
- $|Z_i^{DCA} - Z_V| < 4\sigma_i$

or
- matched to the EMC towers

- Data volume reduction 1:50 ☑
- 50% of tracks from trigger event preserved

Do the preserved tracks include the physics ?



Conclusion 1:
only the low p_T tracks are lost

Tested with p+p @200 GeV, $\eta_q \in [1.0, 1.3]$

Longer-Term Trigger Issues for Spin Program

1) ***Level 2 trigger may become important when full luminosity achieved, SMD/preshower/postshower layers of EMC's are fully operational, J/ψ triggers desired***

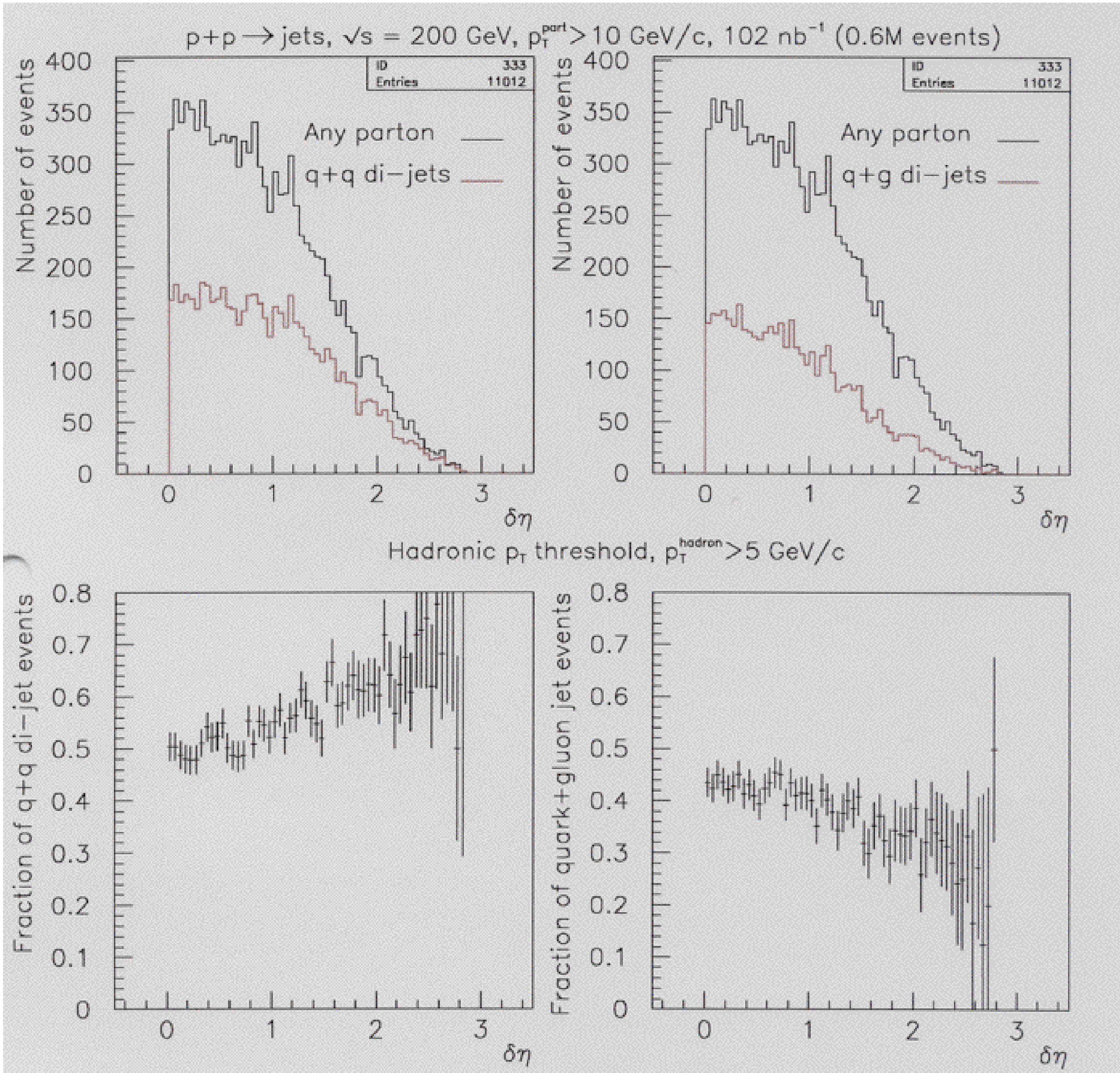
   Can be used, for example, to impose coarse isolation cuts for direct γs at moderate p_T, or to enhance electrons vs. hadrons in trigger

2) ***East-side MWC may be valuable in forming selective trigger for relatively rare dijet events at high $|\Delta\eta|$ and high leading-hadron p_T, where quark-quark scattering dominates***

   qq of interest because polarization effects should be well understood from pQCD and polarized DIS quark helicity distributions – provides sample with expected appreciable non-zero A_{LL}, useful for polarization monitoring at STAR and calibration of RHIC spin vs. DIS

   qq-dominated trigger would demand high EEMC tower above 5 GeV, coupled either with comparably high tower in east half of barrel EMC or sizable charged particle multiplicity in east-side MWC (extends $\Delta\eta$ range, hence qq domination)

Simulated Dijet Yields in STAR with BEMC + EEMC



At design **L** *= 8 ×10*^{31} *cm*$^{-2}$*s*$^{-1}$*, trigger requiring two high EMC towers above* p_T*= 5 GeV/c would yield rate ≈0.3 Hz for dijets with |Δη| ≥ 2.0, enriched to about 70% in quark-quark scattering.* ***Extending trigger coverage to larger |Δη| via east MWC charged-particle multiplicity would increase rate and qq enrichment.***